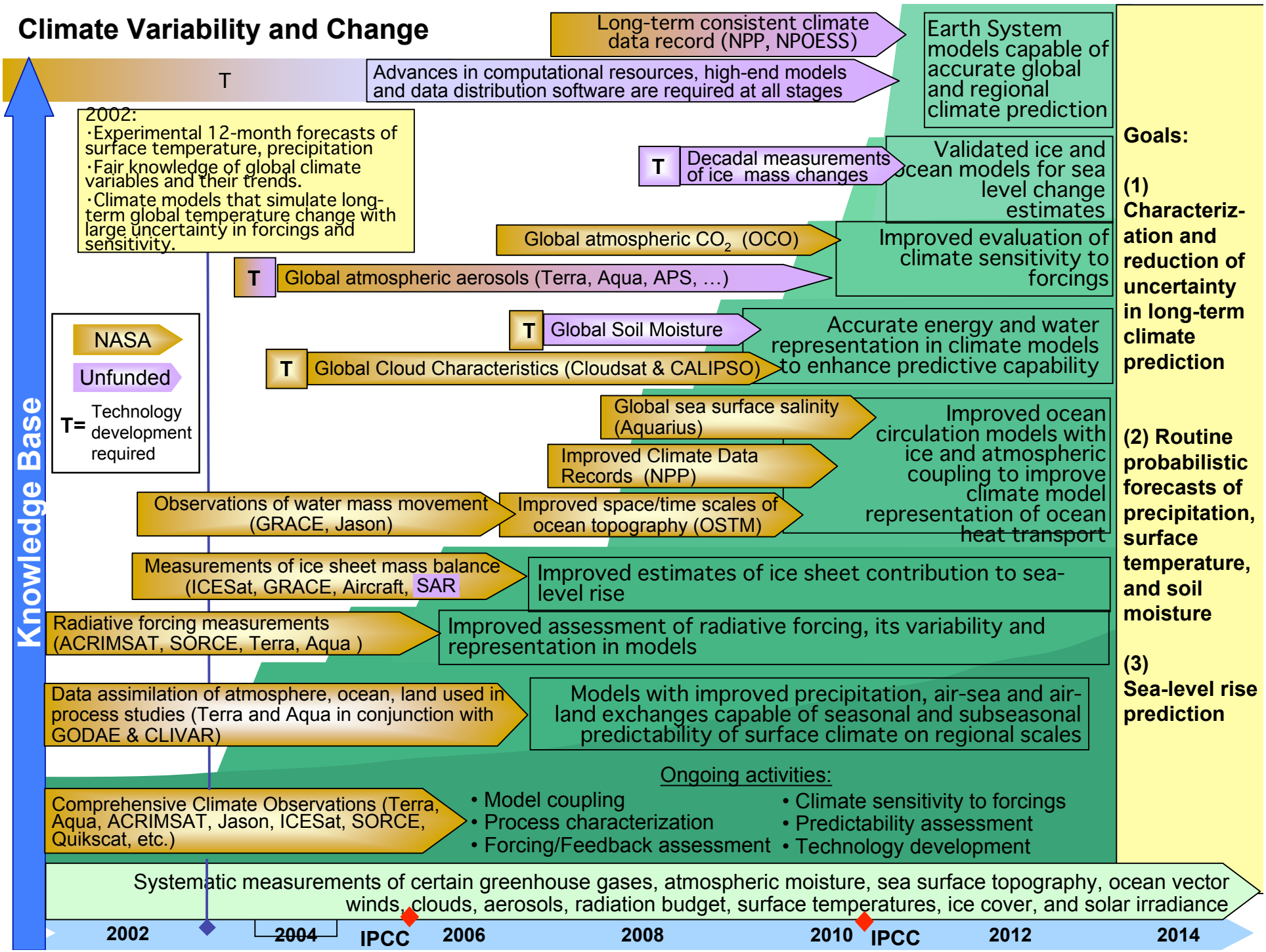
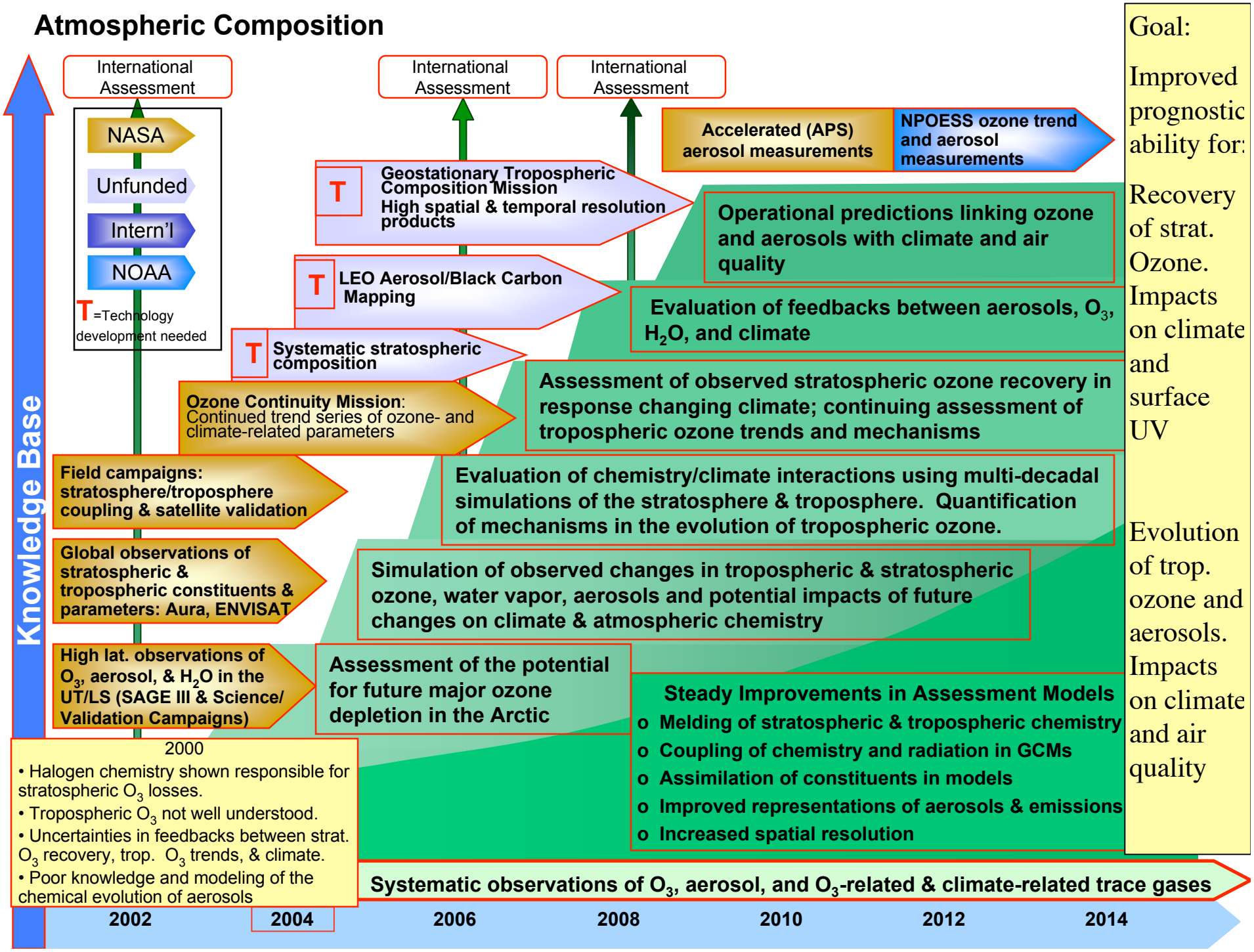
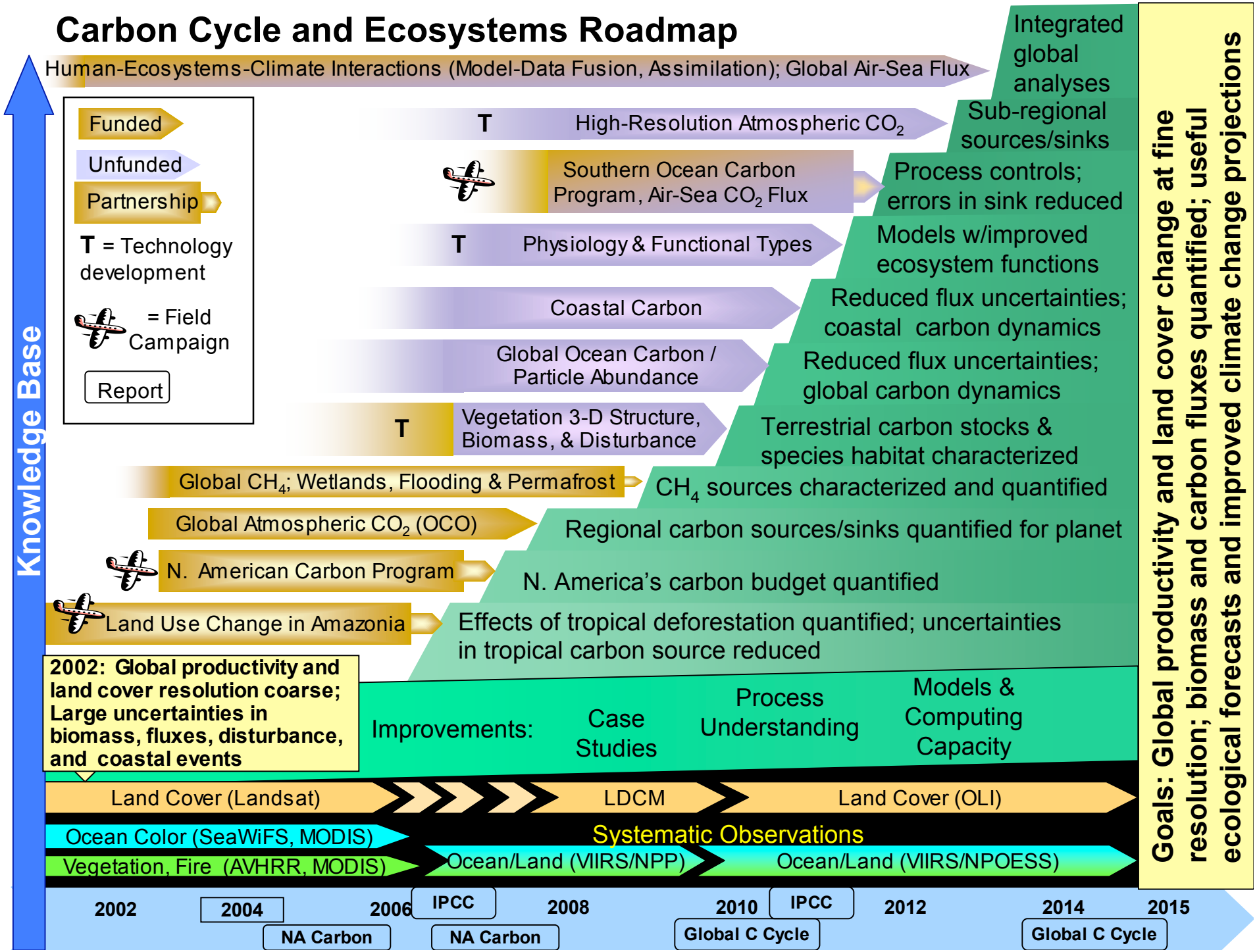
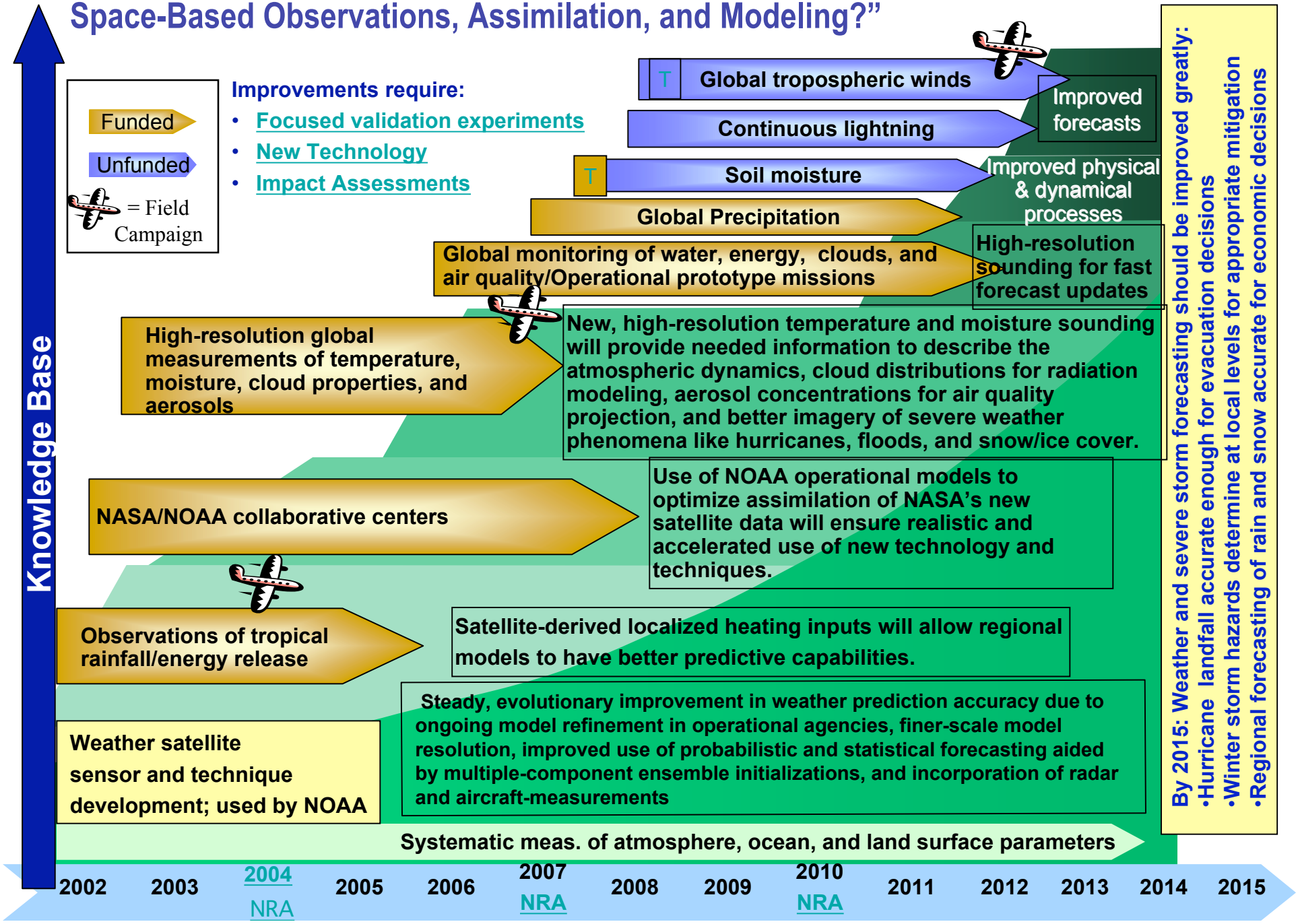
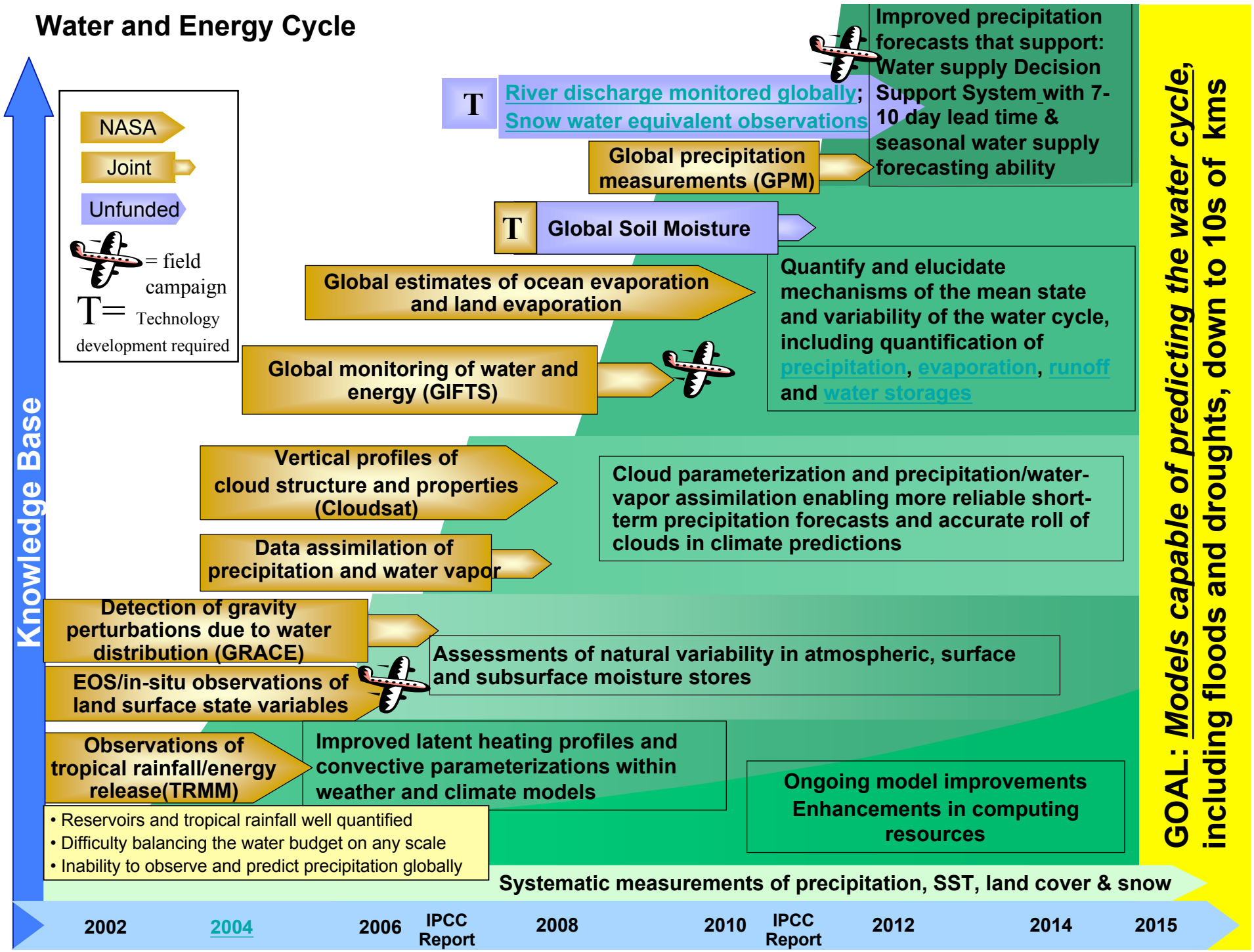

Climate Variability and Change
Knowledge Base
T
Advances in computational resources, high-end models and data distribution software are required at all stages
Long-term consistent climate data record (NPP, NPOESS)
Earth System models capable of accurate global and regional climate prediction
2002:
·Experimental 12-month forecasts of surface temperature, precipitation
·Fair knowledge of global climate variables and their trends.
·Climate models that simulate long-term global temperature change with large uncertainty in forcings and sensitivity.
T
Decadal measurements of ice mass changes
Validated ice and ocean models for sea level change estimates
Global atmospheric CO_2 (OCO)
Improved evaluation of climate sensitivity to forcings
T
Global atmospheric aerosols (Terra, Aqua, APS, …)
NASA
Unfunded
T= Technology development required
T
Global Soil Moisture
Accurate energy and water representation in climate models to enhance predictive capability
T
Global Cloud Characteristics (Cloudsat & CALIPSO)
Global sea surface salinity (Aquarius)
Improved ocean circulation models with ice and atmospheric coupling to improve climate model representation of ocean heat transport
Improved Climate Data Records (NPP)
Observations of water mass movement (GRACE, Jason)
Improved space/time scales of ocean topography (OSTM)
Measurements of ice sheet mass balance (ICESat, GRACE, Aircraft, SAR
Improved estimates of ice sheet contribution to sea-level rise
Radiative forcing measurements (ACRIMSAT, SORCE, Terra, Aqua)
Improved assessment of radiative forcing, its variability and representation in models
Data assimilation of atmosphere, ocean, land used in process studies (Terra and Aqua in conjunction with GODAE & CLIVAR)
Models with improved precipitation, air-sea and air-land exchanges capable of seasonal and subseasonal predictability of surface climate on regional scales
Ongoing activities:
Comprehensive Climate Observations (Terra, Aqua, ACRIMSAT, Jason, ICESat, SORCE, Quikscat, etc.)
• Model coupling
• Process characterization
• Forcing/Feedback assessment
• Climate sensitivity to forcings
• Predictability assessment
• Technology development
Systematic measurements of certain greenhouse gases, atmospheric moisture, sea surface topography, ocean vector winds, clouds, aerosols, radiation budget, surface temperatures, ice cover, and solar irradiance
2002
2004
IPCC
2006
2008
2010
IPCC
2012
2014
Goals:
(1) Characterization and reduction of uncertainty in long-term climate prediction
(2) Routine probabilistic forecasts of precipitation, surface temperature, and soil moisture
(3) Sea-level rise prediction


Atmospheric Composition
Knowledge Base
International Assessment
International Assessment
International Assessment
NASA
Unfunded
Intern'l
NOAA
T=Technology development needed
Accelerated (APS) aerosol measurements
NPOESS ozone trend and aerosol measurements
T Geostationary Tropospheric Composition Mission
High spatial & temporal resolution products
Operational predictions linking ozone and aerosols with climate and air quality
T LEO Aerosol/Black Carbon Mapping
Evaluation of feedbacks between aerosols, O3, H2O, and climate
T Systematic stratospheric composition
Assessment of observed stratospheric ozone recovery in response changing climate; continuing assessment of tropospheric ozone trends and mechanisms
Ozone Continuity Mission: Continued trend series of ozone- and climate-related parameters
Field campaigns: stratosphere/troposphere coupling & satellite validation
Evaluation of chemistry/climate interactions using multi-decadal simulations of the stratosphere & troposphere. Quantification of mechanisms in the evolution of tropospheric ozone.
Global observations of stratospheric & tropospheric constituents & parameters: Aura, ENVISAT
Simulation of observed changes in tropospheric & stratospheric ozone, water vapor, aerosols and potential impacts of future changes on climate & atmospheric chemistry
High lat. observations of O3, aerosol, & H2O in the UT/LS (SAGE III & Science/ Validation Campaigns)
Assessment of the potential for future major ozone depletion in the Arctic
Steady Improvements in Assessment Models
o Melding of stratospheric & tropospheric chemistry
o Coupling of chemistry and radiation in GCMs
o Assimilation of constituents in models
o Improved representations of aerosols & emissions
o Increased spatial resolution
2000
• Halogen chemistry shown responsible for stratospheric O3 losses.
• Tropospheric O3 not well understood.
• Uncertainties in feedbacks between strat. O3 recovery, trop. O3 trends, & climate.
• Poor knowledge and modeling of the chemical evolution of aerosols
Systematic observations of O3, aerosol, and O3-related & climate-related trace gases
2002
2004
2006
2008
2010
2012
2014
Goal:
Improved prognostic ability for:
Recovery of strat. Ozone. Impacts on climate and surface UV
Evolution of trop. ozone and aerosols. Impacts on climate and air quality


Carbon Cycle and Ecosystems Roadmap
Knowledge Base
Human-Ecosystems-Climate Interactions (Model-Data Fusion, Assimilation); Global Air-Sea Flux
Integrated global analyses
Funded
Unfunded
Partnership
T = Technology development
= Field Campaign
Report
T
High-Resolution Atmospheric CO2
Sub-regional sources/sinks
Southern Ocean Carbon Program, Air-Sea CO2 Flux
Process controls; errors in sink reduced
T
Physiology & Functional Types
Models w/improved ecosystem functions
Coastal Carbon
Reduced flux uncertainties; coastal carbon dynamics
Global Ocean Carbon / Particle Abundance
Reduced flux uncertainties; global carbon dynamics
T
Vegetation 3-D Structure, Biomass, & Disturbance
Terrestrial carbon stocks & species habitat characterized
Global CH4; Wetlands, Flooding & Permafrost
CH4 sources characterized and quantified
Global Atmospheric CO2 (OCO)
Regional carbon sources/sinks quantified for planet
N. American Carbon Program
N. America's carbon budget quantified
Land Use Change in Amazonia
Effects of tropical deforestation quantified; uncertainties in tropical carbon source reduced
2002: Global productivity and land cover resolution coarse; Large uncertainties in biomass, fluxes, disturbance, and coastal events
Improvements:
Case Studies
Process Understanding
Models & Computing Capacity
Land Cover (Landsat)
LDCM
Land Cover (OLI)
Ocean Color (SeaWiFS, MODIS)
Systematic Observations
Vegetation, Fire (AVHRR, MODIS)
Ocean/Land (VIIRS/NPP)
Ocean/Land (VIIRS/NPOESS)
2002
2004
2006
IPCC
2008
2010
IPCC
2012
2014
2015
NA Carbon
NA Carbon
Global C Cycle
Global C Cycle
Goals: Global productivity and land cover change at fine resolution; biomass and carbon fluxes quantified; useful ecological forecasts and improved climate change projections

"How Can Weather Forecast Duration and Reliability Be Improved By New Space-Based Observations, Assimilation, and Modeling?"




Water and Energy Cycle
Knowledge Base
NASA
Joint
Unfunded
= field campaign
T= Technology development required
T
River discharge monitored globally;
Snow water equivalent observations
Improved precipitation forecasts that support: Water supply Decision Support System with 7-10 day lead time & seasonal water supply forecasting ability
Global precipitation measurements (GPM)
T
Global Soil Moisture
Global estimates of ocean evaporation and land evaporation
Quantify and elucidate mechanisms of the mean state and variability of the water cycle, including quantification of precipitation, evaporation, runoff and water storages
Global monitoring of water and energy (GIFTS)
Vertical profiles of cloud structure and properties (Cloudsat)
Cloud parameterization and precipitation/water-vapor assimilation enabling more reliable short-term precipitation forecasts and accurate roll of clouds in climate predictions
Data assimilation of precipitation and water vapor
Detection of gravity perturbations due to water distribution (GRACE)
Assessments of natural variability in atmospheric, surface and subsurface moisture stores
EOS/in-situ observations of land surface state variables
Observations of tropical rainfall/energy release(TRMM)
Improved latent heating profiles and convective parameterizations within weather and climate models
Ongoing model improvements
Enhancements in computing resources
• Reservoirs and tropical rainfall well quantified
• Difficulty balancing the water budget on any scale
• Inability to observe and predict precipitation globally
Systematic measurements of precipitation, SST, land cover & snow
GOAL: Models capable of predicting the water cycle, including floods and droughts, down to 10s of kms
2002
2004
2006
IPCC Report
2008
2010
IPCC Report
2012
2014
2015

How is the Earth's surface being transformed and how can such information be used to predict future changes?

Overall Goals:

- Determine the nature of deformation at plate boundaries and the implications for earthquake hazards
- Determine how tectonics and climate interact to shape the Earth's surface and create natural hazards
- Quantify the interactions among ice masses, oceans, and the solid Earth and their implications for sea level

NASA

Joint

Internat'l

Unfunded

T=Technology Development required

Knowledge Base

T **Advanced Gravity Measurements from space**

Increased predictive capability for earthquakes and sea level based on redistribution of mass

GPS limb sounding (COSMIC)

Long wavelength gravity field, better atmospheric structure to improve GRACE data analysis yielding improved sea-level change estimates

Earth Scope: InSAR, PBO, USArray, SAFOD

T **Extremely accurate space-borne radar geodetic imaging (InSAR)**

Global and regional volcanic inflation, flooding, land and coastal erosion, fault strain, fire hazard, tectonic strain, precision topography

Local continuous observation of deformation using geodetic imaging from LIDAR and InSAR for prediction of eruption, landslide, flooding

T **Airborne repeat pass InSAR & spaceborne lidar**

The EarthScope program seeks crustal structure and high temporal and spatial resolution of geodetic imaging of regional deformation processes for improved predictability of earthquake and volcanic activity

Global gravity, glacial volume ocean and land topography measurements (GRACE, Icesat, JASON)

Monthly measurements of the distribution of water within the earth system, leading to increased understanding of sea level change, drought, flooding, & water resources

Models & Prediction: Improved resolution of stress and strength of the crust, fault interaction models, volcano eruption predictions, geodetic reference frame, and Mass flux modeling.

Moderate resolution global geodetic imaging radar (SRTM)

10 fold improvement in global topography yields major impacts throughout earth science (water resources, floods, ecology, crustal dynamics, etc. and applications to infrastructure, aviation, etc.)

NASA Geodetic Network

global geodetic networks provide real time reference frame for surface deformation, real time precision positioning for observations and applications

Prediction of volcanic activity somewhat reliable at week-to- month-scale, while earthquake prediction more reliable at decade-to-century-scales. High uncertainty in sea-level prediction.

2004 2006 2008 2010 2012 2014

Back